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(54) Ventilator system

Beatmungsgerät

Ventilateur

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(56) References cited:
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Description

[0001] The present invention relates to a method, for use with a ventilator system, for measuring pressure in a lung system during respirator treatment in which gas is carried to the lung system during inspiration via a first separate gas line and carried away from the lung system during expiration via a second separate gas line.

[0002] The present invention also relates to a ventilator system comprising an inspiratory line, an expiratory line, a connector device, devised for placement at least in part in a patient's trachea, facing the carina, in order to connect the patient to the ventilator system, an inspiratory pressure meter, arranged to sense pressure in the inspiratory line .an expiratory pressure meter, arranged to sense pressurce in the expiratory line.

[0003] One such ventilator system is described in WO-91/19526 and comprises a ventilator to which an inspiratory line and an expiratory line are connected. The inspiratory line and the expiratory line are attached, in turn, via a Y-piece to which a tracheal tube is also attached. The tracheal tube is intended for insertion into a patient's trachea in order to carry breathing gas to/from the patient's lungs. An inspiratory pressure meter is arranged in the ventilator unit to sense pressure in the ventilator system's inspiratory section and an expiratory pressure meter for sensing the pressure in the ventilator system's expiratory section.

[0004] Accurate sensing of pressure is important, the pressure in the patient's lung system in particular, i.e. pressure at the carina (the ridge separating the openings of the main bronchi at their junction with the trachea). Mainly as a result of the fall in pressure in the tracheal tube when breathing gas flows through it, the ventilator's pressure meters do not measure pressure in the lungs. Compensation for this fall in pressure must be made to obtain information on pressure at the carina, and determining this compensation can be difficult. The fall in pressure is dependent on e.g. flow in the tracheal tube. A number of methods can be used for calculating compensation for the fall in pressure.

[0005] US-A-4,265,237 describes a ventilator system in which a special pressure measurement tube is inserted into the tracheal tube to measure pressure in the lower part of same. If the pressure measurement tube is inserted all the way down to the carina, pressure can be measured there with good accuracy. However, blockage of the pressure measurement tube by secretions and other materials formed in the patient's lungs and lower airways is a problem which can occur in this type of measurement. So this procedure is very unreliable.

[0006] One object of the present invention is to solve the problems in known systems and achieve a ventilator system in which pressure measurements in the lungs can be performed simply and safely and with accurate results.

[0007] This object is achieved in accordance with the invention in that the pressure in the lung system is measured during inspiration by measurement of pressure in the second separate gas line and/or pressure in the lung system is measured during expiration by measurement of pressure in the first separate gas line.

[0008] This means that all gas flows to the patient's lungs through the first gas line during inspiration. Since no gas flows through the second line, no drop in pressure occurs across same. Pressure in the second gas line will then be the same as pressure at the carina. Measurement at some point in the second gas line will then also designate pressure at the carina.

[0009] SE-B-430 213 describes a ventilator system with two ventilator units. One of the ventilator units is set up as an ordinary ventilator, i.e. with inspiratory and expiratory lines connected to a common tracheal tube. The second ventilator unit has a separate supply line arranged inside the tracheal tube. In principle, breathing gas can be supplied, via the supply line, from the second ventilator unit, and gas can be carried away from the patient via the tracheal tube and expiratory line. However, this ventilator system is devised with a pressure measurement tube, like the one described above, to measure pressure in the carina.

[0010] In the corresponding manner as in inspiration, all gas expired during expiration flows through the second gas line. No gas then flows in the first gas line, so there is no fall in pressure in this line either. Measurement of pressure in the first gas line also yields the pressure at the carina. Since new gas flows through the first gas line in every inspiration, this line is kept free from secretions and the like.

[0011] A ventilator system is achieved in accordance with the invention when the ventilator system according to the preamble is devised so the connector device comprises a first gas line, connected to the inspiratory line, and a second gas line, connected to the expiratory line, said gas lines being arranged so gas from the inspiratory valve flows through the inspiratory line and the first gas line towards the patient's trachea and gas from the patient flows through the second gas line and expiratory line towards the expiratory valve whereby gas only flows through the gas lines in one direction, and the expiratory pressure meter is adapted to measure pressure in the expiratory line during inspiration and the inspiratory pressure meter is adapted to measure pressure in the inspiratory line during expiration, whereby pressure in the patient's lungs is measurable.

[0012] Other advantageous embodiments of the invention are set forth in the dependent claims.

[0013] The invention will be described below in greater detail, referring to the figures in which

FIG. 1 shows a diagram of the most important components in a ventilator system, connected to a patient, according to the invention;

FIGS. 2A-2C show different designs for a tracheal tube in the ventilator system according to the invention;

FIG. 3 shows breathing curves and
FIG. 4 shows an alternative design for the ventilator system according to the invention.

[0014] FIG. 1 shows the lower part of a patient's trachea 2. It opens onto the carina 4 from which the main bronchi 6A, 6B lead down into the lungs. A tracheal tube 8 is in the trachea 2 and affixed with a cuff 10. The cuff 10 is inflatable and prevents gas from passing through the trachea around the tracheal tube 8. The tracheal tube 8 has a first gas line 12, through which breathing gas is supplied to the patient's lungs during inspiration, and a second gas line 14, through which breathing gas is carried away from the patient's lungs during expiration.

[0015] Here, the first gas line 12 is connected to an inspiratory line 16. The inspiratory line 16 is connected to an inspiratory valve 18 which regulates the supply of breathing gas to the inspiratory line 16. A flow meter 20 is arranged to measure the flow of breathing gas from the inspiratory valve 18, and an inspiratory pressure meter 22 is arranged to measure pressure in the inspiratory line 16.

[0016] In the corresponding manner, the second gas line 14 is connected to an expiratory line 24 which, in turn, is connected to an expiratory valve 26. The expiratory valve 26 regulates the flow of gas from the patient's lungs and/or pressure in the expiratory line 24 in the end phase of expiration. Here, a second flow meter 28 is arranged in the expiratory line 24 to measure the flow of breathing gas, and an expiratory pressure meter 30 is arranged to measure pressure in the expiratory line 24.

[0017] The inspiratory valve 18, the first flow meter 20, the inspiratory pressure meter 22, the expiratory valve 26, the second flow meter 28 and the expiratory pressure meter 30 can all be arranged in a ventilator unit (not shown). One such ventilator could be e.g. a Servo Ventilator 300, Siemens-Elema AB, Solna, Sweden. The ventilator unit can also consist of a ventilator unit according to the previously cited document, WO 91/19526 (Servo Ventilator 900 C, Siemens-Elema AB).

[0018] The unique features of the invention are that gas to/from the patient passes through completely separate gas lines 12, 14 and, particularly, that pressure at the carina is measured with the expiratory pressure meter 30 during inspiration and vice-versa. In this matter, pressure at the carina 4 can be measured with much greater accuracy than hitherto. Moreover, no calculation program is needed to determine compensation for the fall in pressure etc. in the tracheal tube. During inspiration, when breathing gas is supplied via the inspiratory line 16 and the first gas line 12, no gas flows in the second gas line 14 and the expiratory line 24. The expiratory pressure meter 30 then measures pressure at the carina 4, since there is no fall in pressure in the expiratory line 24 and the second gas line 14.

[0019] A small flow is permissible in the second gas line 14, as long as the fall in pressure which then develops there is negligible. Any fall in pressure can be measured with good accuracy when the flow is supplied in the first gas line 12, and pressure is measured in the second gas line 14.

[0020] In the corresponding manner, all gas flows through the second gas line 14 and the expiratory line 24 during expiration. No gas then flows through the first gas line 12 and the inspiratory line 16, so the fall in pressure across these lines is zero. The inspiratory pressure meter 22 then measures pressure at the carina 4.

[0021] The tracheal tube 8 with the first gas line 12 and the second gas line 14 can be devised in a plurality of ways, as shown in the tracheal tube cross-sections in FIGS. 2A, 2B and 2C. As in FIG. 1, FIG. 2A shows the first gas line 12 arranged inside the second gas line 14. The first gas line 12 can also be arranged parallel to and alongside the second gas line 14 (FIG. 2B) or integrated into the second gas line 14 (FIG. 2C). Additional embodiments of the tracheal tube 8, with two separate gas lines 12, 14, can be simply achieved.

[0022] The embodiment with separate gas lines 12, 14 also makes possible simpler pressure triggering in spontaneous breathing. Since the pressure meters 22, 30 measure pressure at the carina 4, any attempt at spontaneous breathing by the patient will be detected in the form of a fall in pressure at the carina 4. An inspiration can then be immediately supplied to the patient. In the corresponding manner, any attempt at expiration by the patient is quickly detected as an increase in pressure in the carina 4, and an expiration can then be triggered in a simpler manner than hitherto.

[0023] The trachea normally forms a dead space, i.e. gas which is rebreathed at the start of an inspiration. The entire tracheal tube forms a dead space to an intubated patient. Another advantage of the separate administration and removal of breathing gas is that the system minimizes the dead space.

[0024] The pressure meters 22, 30 can be simply checked against each other if pressure readings during inspiratory and expiratory pauses respectively, when no gas flows through any of the line 12, 14, 16, 24, are compared.

[0025] Triggering inspirations on the basis of flow measurements instead of pressure measurements, or a combination thereof, is desired in certain instances. A continuous basic flow of gas is then usually supplied via the inspiratory line 16. Flow is affected when the patient attempts to inhale, and an inspiration is triggered when flow has been affected to a sufficient degree. To minimize the impact of basic flow on pressure measurements in the present ventilator system, the system is devised in a specific manner described in greater detail in comments on FIG. 3.

[0026] FIG. 3 is a flow and time diagram showing a breathing curve 32. In FIG. 3, the breathing curve 32 covers two breathing cycles, a first inspiration 34A, a first expiration 34B, a second inspiration 34C and a sec-

ond expiration 34D. Peak values for inspiratory flows and expiratory flows were set at 100%. They can be measured from breathing cycle to breathing cycle. The second flow meter measures flow during expiration. When flow drops to a pre-defined percentage of the peak value for flow, a weak basic flow of breathing gas is activated from the inspiratory valve. In this instance, 10% of the peak value for flow during the current expiratory 34B was used as the defined percentage. The patient will then be able to trigger an inspiration based on flow measurement. When measured flow indicates a pre-defined inspiratory effort by the patient, as shown at point 38, the ventilator system is activated to supply an inspiration.

[0027] The basic flow supplied is small, and the fall in pressure in the second gas line 14 is therefore also small, so the pressure reading obtained by the expiratory pressure meter 30 can be used for relatively accurate determination of e.g. PEEP. A weighted value between the pressure measured by the inspiratory pressure meter 22 and the pressure measured by the expiratory pressure meter 30 can be used to attain greater accuracy.

[0028] The modest amount of breathing gas supplied during the latter part of expiration also conveys additional advantages. Gas evacuation of the lung is slight at the end of expiration and can be improved when the small additional gas flow supplied picks up some of the expired gas below the gas lines 12, 14. In this manner, the volume of dead space can be further reduced and CO_2 flushed out of the lungs. This flow can be eliminated in the breaths in which measurements are made of the concentration of expired CO_2.

[0029] Limits other than 10% of the peak value for flow are also possible in determining when the basic flow is to be added.

[0030] FIG. 4 shows an alternative embodiment of the ventilator system according to the invention. Components which can be identical have the same designations as in FIG. 1. So they do not need to described again. The major difference between the ventilator system according to FIG. 4 and the ventilator system according to FIG. 1 is that the ventilator in FIG. 4 has a separate tracheal tube 40, with only one gas channel, inserted into the patient's trachea 2 to carry away expired breathing gas in expiration. Gas supplied to the patient during inspiration is instead carried through a tracheotomy connector 42 to the patient's airway 2. In this instance, the tracheal tube 40 can be made relatively short and even avoid, in principle, passing the patient's vocal cords and damaging same.

Claims

1. A ventilator system comprising an inspiratory line (16), an inspiratory valve (18) which regulates the supply of breathing gas to the inspiratory line (16), an expiratory line (24), an expiratory valve (26) which regulates the flow of gas from the expiratory line (24), a connector device (8, 12, 14; 40, 42) devised for placement at least in part in a patient's trachea, facing the carina, in order to connect the patient to the ventilator system, an inspiratory pressure meter (22), arranged to sense pressure in the inspiratory line (16) and an expiratory pressure meter (30) arranged to sense pressure in the expiratory line (24), **characterized in that** the connector device (8, 12, 14; 40, 42) comprises a first gas line (12; 42), connected to the inspiratory line (16), and a second gas line (14; 40), connected to the expiratory line (24), said gas lines (12, 14; 40, 42) being arranged so gas from the inspiratory valve (18) flows through the inspiratory line (16) and the first gas line (12; 42) towards the patient's trachea and gas from the patient flows through the second gas line (14; 40) and the expiratory line (24) towards the expiratory valve (26), whereby gas only flows through the gas lines (12, 14; 40, 42) in one direction, and the expiratory pressure meter (30) is adapted to measure pressure in the expiratory line (24) during inspiration and the inspiratory pressure meter is adapted to measure pressure in the inspiratory line (16) during expiration, whereby pressure in the patient's lung is measurable.

2. A ventilator system according to claim 1, **characterized in that** the first gas line (12; 42) has a smaller cross-section than the second gas line (14; 40).

3. A ventilator system according to claim 1 or 2, **characterized in that** the connector device (8) is a tracheal tube.

4. A ventilator system according to claim 3, **characterized in that** the first gas line (12) is arranged inside the second gas line (14).

5. A ventilator system according to claim 4, **characterized in that** the first gas line (12) is arranged alongside and parallel to the second gas line (14).

6. A ventilator system according to claim 1 or 2, **characterized in that** the first gas line (42) consists of a tracheotomy connector, and the second gas line (40) consists of a tracheal tube.

7. A ventilator system according to any of claims 1-6, **characterized in that** there is a valve system (18), connected to the inspiratory line (16) to supply a pre-defined flow of gas through the inspiratory line (16), a first flow meter (20), arranged to measure the flow of gas in the inspiratory line (16), and a second flow meter (28), arranged to measure the flow of gas in the expiratory line (24), said valve system (18) being devised to supply a pre-defined continu-

ous flow of gas, during at least a latter part of an expiratory phase when the flow measured by the second flow meter (28) has dropped below a threshold value, said threshold value preferably consisting of a pre-defined percentage of a peak value for flow measured by the second flow meter (28) during the expiratory phase.

Patentansprüche

1. Beatmungsgerätsystem mit einer Inspirationsleitung (16), einem Inspirationsventil (18), das die Zufuhr von Atemgas zu der Inspirationsleitung (16) regelt, einer Exspirationsleitung (24), einem Exspirationsventil (26), das den Gasfluss von der Exspirationsleitung (24) regelt, einer Anschlussvorrichtung (8, 12, 14; 40, 42), die für die Anordnung zumindest teilweise in der Trachea eines Patienten in Richtung auf die Carina ausgebildet ist, um den Patienten mit dem Beatmungsgerätsystem zu verbinden, einem inspiratiorischen Druckmesser (22), angeordnet, um den Druck in der Inspirationsleitung (16) abzufühlen, und einem exspiratorischen Druckmesser (30), angeordnet, um den Druck in der Exspirationsleitung (24) abzufühlen, **dadurch gekennzeichnet, dass** die Anschlussvorrichtung (8, 12, 14; 40, 42) eine erste an die Inspirationsleitung (16) angeschlossene Gasleitung (12; 42)und eine zweite an die Exspirationsleitung (24) angeschlossene Gasleitung (14; 40) aufweist, wobei diese Gasleitungen (12, 14; 40, 42) so angeordnet sind, dass Gas von dem Inspirationsventil (18) durch die Inspirationsleitung (16) und die erste Gasleitung (12; 42) in Richtung auf die Trachea des Patienten fließt und Gas von dem Patienten durch die zweite Gasleitung (14; 40) und die Exspirationsleitung (24) in Richtung des Exspirationsventils (26) fließt, wodurch Gas durch die Gasleitungen (12, 14; 40, 42) nur in einer Richtung fließt, und dass der exspiratorische Druckmesser (30) angepasst ist, den Druck in der Exspirationsleitung (24) während der Inspiration zu messen und der inspiratorische Druckmesser angepasst ist, den Druck in der Inspirationsleitung (16) während der Exspiration zu messen, wodurch der Druck in den Patientenlungen messbar ist.

2. Ein Beatmungsgerätsystem gemäß Anspruch 1, **dadurch gekennzeichnet, dass** die erste Gasleitung (12; 42) einen kleineren Querschnitt hat als die zweite Gasleitung (14; 40).

3. Ein Beatmungsgerätsystem nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die Anschlussvorrichtung (8) ein Trachealtubus ist.

4. Ein Beatmungsgerätsystem nach Anspruch 3, **dadurch gekennzeichnet, dass** die erste Gasleitung (12) innerhalb der zweiten Gasleitung (14) angeordnet ist.

5. Ein Beatmungsgerätsystem nach Anspruch 4, **dadurch gekennzeichnet, dass** die erste Gasleitung entlang und parallel zu der zweiten Gasleitung (14) angeordnet ist.

6. Ein Beatmungsgerätsystem nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die erste Gasleitung (42) aus einem Tracheotomieanschluss und die zweite Gasleitung (40) aus einer Trachealtubus besteht.

7. Ein Beatmungsgerätsystem nach einem der Ansprüche 1-6, **gekennzeichnet durch** ein an die Inspirationsleitung (16) angeschlossenes Ventilsystem (18), um über die Inspirationsleitung (16) einen vorbestimmten Gasfluss zuzuführen, einen ersten Flussmesser (20), angeordnet, um den Gasfluss in der Inspirationsleitung (16) zu messen, und einen zweiten Flussmesser (28), angeordnet, um den Gasfluss in der Exspirationsleitung (24) zu messen, wobei das Ventilsystem (18) ausgebildet ist, während zumindest eines letzteren Teils einer Exspirationsphase, wenn der **durch** den zweiten Flussmesser (28) gemessene Fluss unter einen Schwellwert abgesunken ist, einen vorbestimmten kontinuierlichen Gasfluss zuzuführen, wobei der Schwellwert vorzugsweise aus einem vorbestimmten Prozentsatz eines Spitzenwertes des **durch** den zweiten Flussmesser (28) während der Exspirationsphase gemessenen Flusses besteht.

Revendications

1. Système ventilateur comportant une ligne (16) d'inspiration, une vanne (18) d'inspiration qui régule l'alimentation en gaz de respiration vers la ligne (16) d'inspiration, une ligne (24) d'expiration, une vanne (26) d'expiration qui régule le débit gazeux provenant de la ligne (24) d'expiration, un dispositif (8, 12, 14 ; 40, 42) formant connecteur conçu pour être placé au moins en partie dans une trachée d'un patient, faisant face à la carine, afin de relier le patient au système ventilateur, un dispositif (22) de mesure de pression d'inspiration, disposé pour détecter une pression dans la ligne (16) d'inspiration et un dispositif (30) de mesure de pression d'expiration disposé pour détecter une pression dans la ligne (24) d'expiration, **caractérisé en ce que** le dispositif (8, 12, 14 ; 40, 42) formant connecteur comporte une première ligne (12 ; 42) de gaz reliée à la ligne (16) d'inspiration, et une deuxième ligne (14 ; 40) de gaz reliée à la ligne (24) d'expiration, les lignes (12, 14 ; 40, 42) de gaz étant disposées de sorte que du gaz provenant de la vanne (18) d'inspiration passe par

la ligne (16) d'inspiration et la première ligne (12 ; 42) de gaz en direction de la trachée du patient et du gaz en provenance du patient passe par la deuxième ligne (14 ; 40) de gaz et la ligne (24) d'expiration en direction de la vanne (26) d'expiration, du gaz passant uniquement par les lignes (12, 14 ; 40, 42) de gaz dans un sens, et le dispositif (30) de mesure de pression d'expiration est conçu pour mesurer une pression dans la ligne (24) d'expiration pendant l'inspiration et le dispositif de mesure de pression d'inspiration est conçu pour mesurer de la pression dans la ligne (16) d'inspiration pendant l'expiration, la pression dans les poumons du patient pouvant ainsi être mesurée.

2. Système ventilateur suivant la revendication 1, **caractérisé en ce que** la première ligne (12 ; 42) de gaz a une section transversale plus petite que celle de la deuxième ligne (14 ; 40) de gaz.

3. Système ventilateur suivant la revendication 1 ou 2, **caractérisé en ce que** le dispositif (8) formant connecteur est un tube de trachée.

4. Système ventilateur suivant la revendication 3, **caractérisé en ce que** la première ligne (12) de gaz est disposée à l'intérieur de la deuxième ligne (14) de gaz.

5. Système ventilateur suivant la revendication 4, **caractérisé en ce que** la première ligne (12) de gaz est disposée le long de la deuxième ligne (14) de gaz et parallèlement à celle-ci.

6. Système ventilateur suivant la revendication 1 ou 2, **caractérisé en ce que** la première ligne (42) de gaz est constituée d'un connecteur de trachéotomie, et la deuxième ligne (40) de gaz est constituée d'un tube de trachée.

7. Système ventilateur suivant l'une quelconque des revendications 1 à 6, **caractérisé en ce qu'**il y a un système (18) de vanne, relié à la ligne (16) d'inspiration pour fournir un débit prédéfini de gaz par l'intermédiaire de la ligne (16) d'inspiration, un premier dispositif (20) de mesure de débit, disposé pour mesurer le débit gazeux dans la ligne (16) d'inspiration, et un deuxième dispositif (28) de mesure de débit, disposé pour mesurer le débit de gaz dans la ligne (24) d'expiration, le système (18) de vanne étant conçu pour fournir un débit gazeux continu prédéfini, pendant au moins une partie ultérieure d'une phase d'expiration lorsque le débit mesuré par le deuxième dispositif (28) de mesure de débit a chuté en dessous d'une valeur seuil, la valeur seuil étant constituée de préférence d'un pourcentage défini à l'avance d'une valeur pic pour une mesure de débit par le deuxième dispositif (28) de mesure de débit pendant la phase d'expiration.

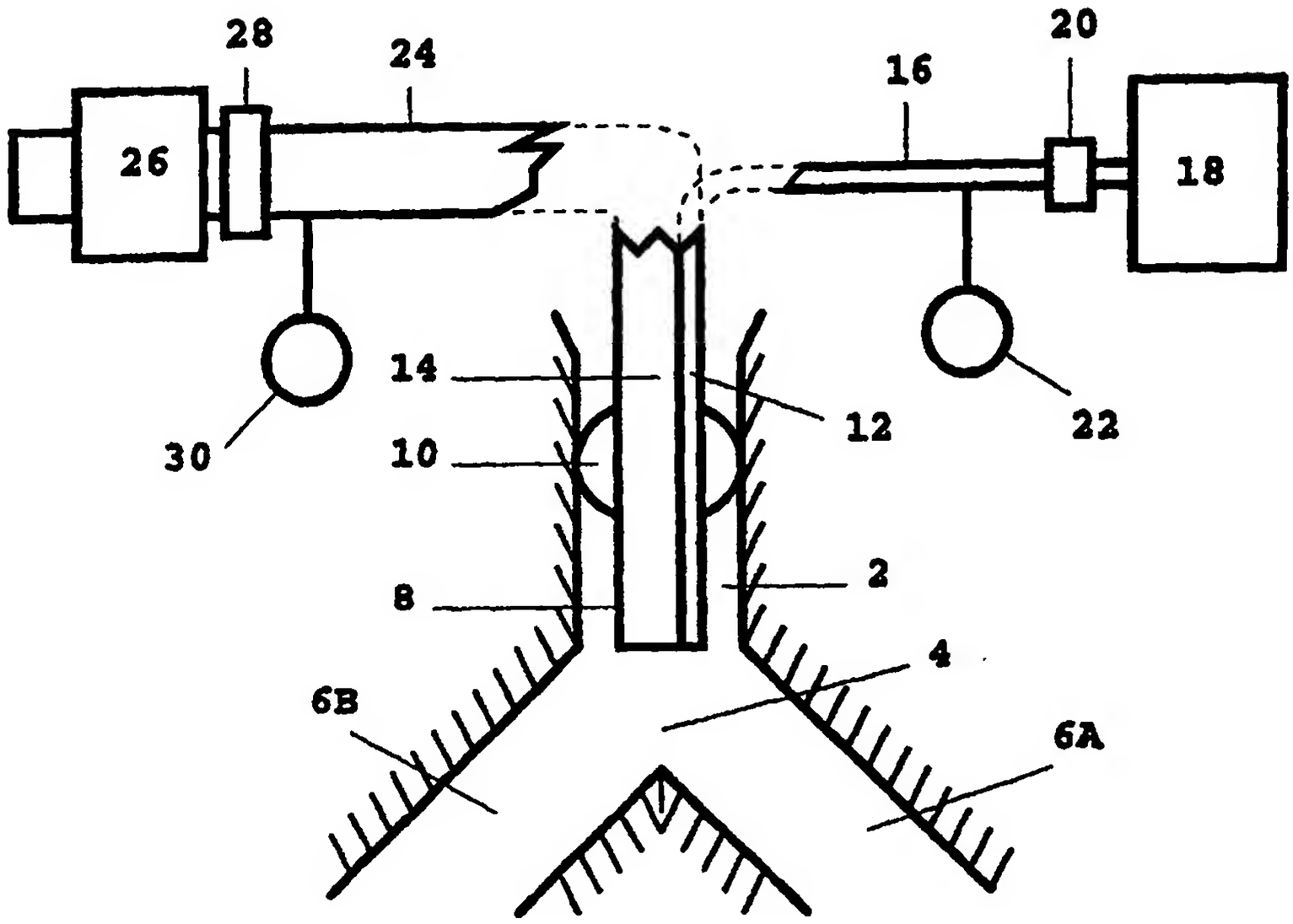

FIG. 1

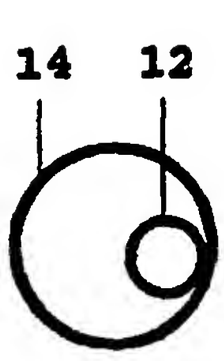

FIG. 2A

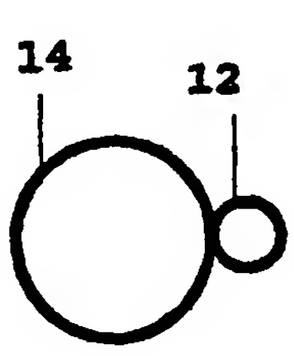

FIG. 2B

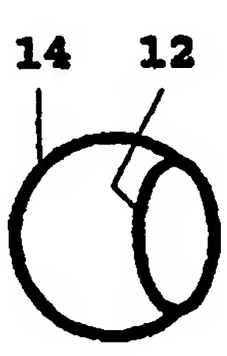

FIG. 2C

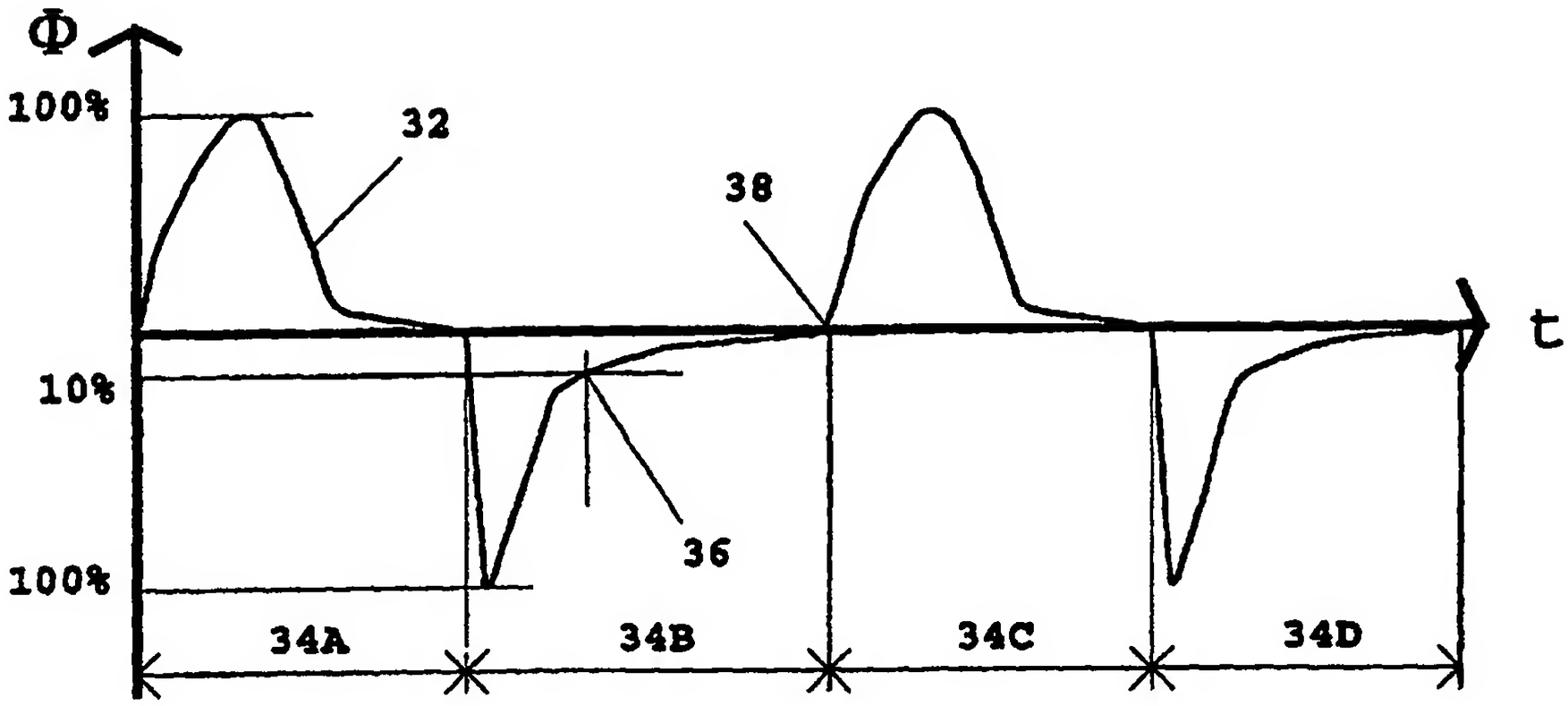
Φ
100%
32
38
t
10%
36
100%
34A
34B
34C
34D

FIG. 3

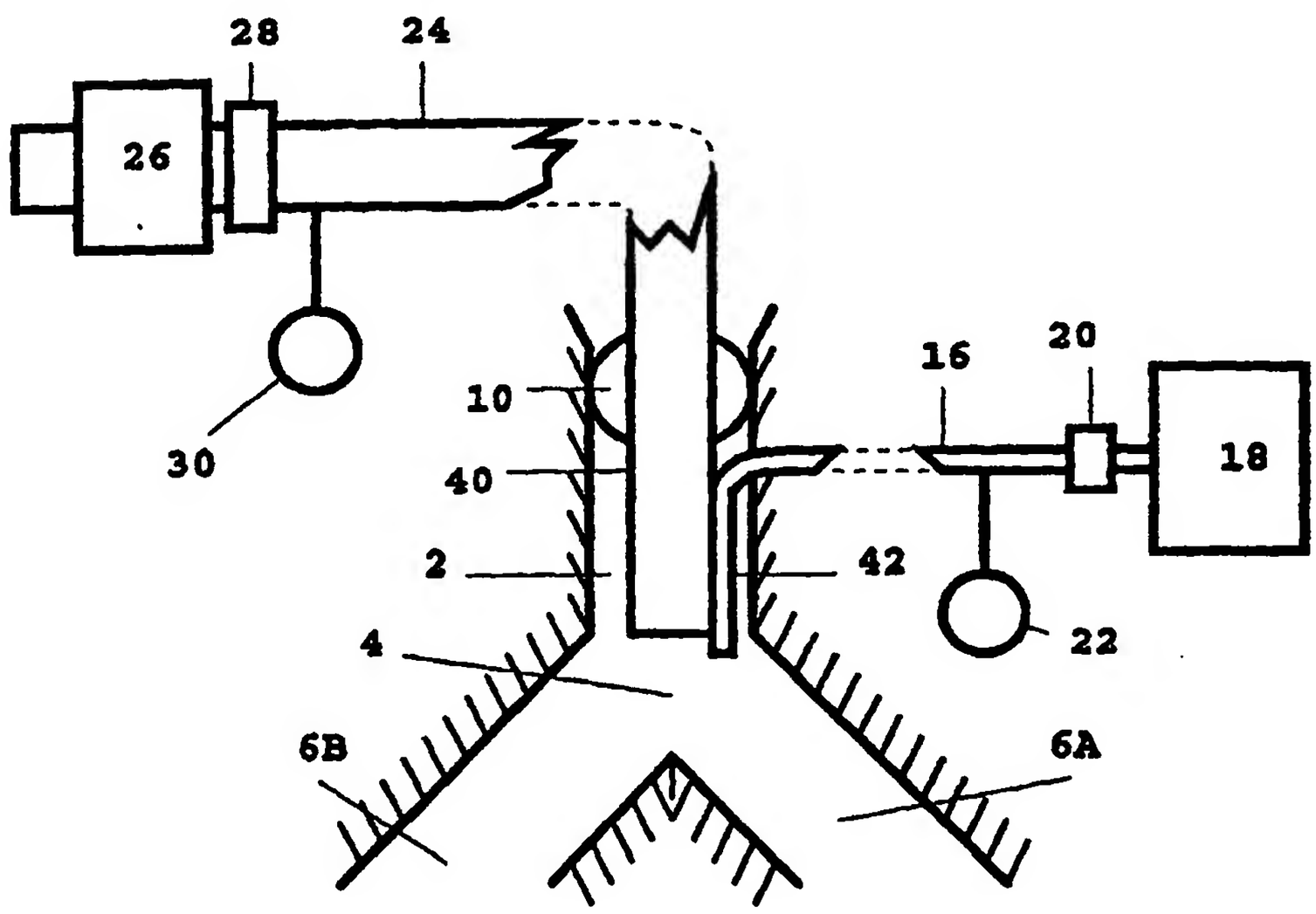
28
24
26
30
10
40
2
4
6B
16
20
18
42
22
6A

FIG. 4